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The Influence of wet Weather upon parasitic Fungi*

BY BYRON D. HALSTED

April and May of the present year were interesting to both the meteorologist and mycologist. There is doubtless some vital connection between the weather and the development of parasitic fungi, and it is the province of this paper to record some observations, with the hope that it may help to furnish data of value both to science and crop growing.

The following facts are gathered from the New Jersey Weather Service. For April the average precipitation for the whole state was 3.77 inches, or .40 inch above the normal. It rained on 12 days, 22 were cloudy and 8 were clear. In short, it was an overcast, but not a very wet month.

For May the average precipitation was 7.00 inches, or 2.82 inches above the normal. It rained on 17 days, and there were only 7 clear days out of the 31. In the language of the report, "The precipitation during the month of May, 1898, will long be remembered as one of the greatest on record."

The following are some of the notes upon fungi for the spring of the present year:

The hollyhock rust, *Puccinia malvacearum* Mont., has been much more abundant and destructive this season than ever before. It came into spore production early and ruined many beds of plants. Leaves of the ordinary size sometimes had hundreds of spore sori that quickly became coated over with the promycelia and sporidia.

Early in May the cedar apples in the southern part of the state were abundant and resembled modern chrysanthemums in their large size. Many trees were seen where *Gynosporangium macropus* Link., covered the branches and main stem of the trees (*Juniperus Virginiana* L.) with the gelatinous horns.

Upon May 28 it was reported to me by a local botanist that the Azalea apples (*Exobasidium azaliae* Peck.) were unusually abundant upon *Azalia nudiflora* (L.) and upon the same date the writer inspected many paeonia plants that while pushing their flower stalks had all the inner leaves of the bushes overrun and blighted by a dense growth of *Botrytis vulgaris* Fr. It was a clear case of the fungus flourishing as a parasite upon the spring herbage.

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* Read before Section G. of the A. A. A. S. at its Boston meeting, August 23, 1898.

Among wild plants the large succulent foliage of the mandrake proved especially susceptible. As early as May 15th a *Ramularia* was found producing large brown patches, and soon after the rust (*Puccinia podophyllii* Schr.) appeared in great abundance, and within two weeks scarcely a plant could be found with the leaves not covered with the telentospore form of the rust.

A very large per cent. of the plants of *Claytonia Virginica* L. were ruined by *Aecidium Mariae-Wilsoni* Clint., and the smut (*Ustilago ornithogali* Schm.) ravaged *Erythronium Virginicum* Sm.

Some plants of *Onagra biennis* (L.) were affected with *Synchytrium fulgens* Schr., covering leaves and stem alike completely. The same was true of *Aecidium epilobii* DC. The rust *Puccinia curtipes* Howe on *Saxifraga Virginiana* Michx. was very abundant and *Plasmopara geranii* (Pk.), and *Peronospora parasitica* (Pers.) were largely in evidence upon their respective hosts. *Cystopus candidus* was very common on shepherds' purse, while *Cerastium vulgatum* was literally overrun by *Isariopsis pusilla* Fr.

In the fruit garden the blackberries suffered unusually from the rust, *Caeoma nitens* Schw., in May and June; *Monilia fructigena* secured the cherry crop, and in the grain fields the rye showed much *Urocystis occulta* Wallr., and a still larger percentage of wheat was destroyed by *Ustilago tritici* P., while some fields of oats were ruined by *Ustilago avenae* (Pers.).

In the orchards the members of the genus *Exoascus* have been remarkably abundant, upon the cherry trees; and never before, to my knowledge, has there been any such wide-spread outbreak of peach curl (*Exoascus deformans* (Berk.)) in this country as during the spring of 1898. In some orchards every leaf was more or less affected, and young trees recently set were similarly diseased. In the "Rural New Yorker," under date of June 18th, there is an editorial upon the subject in which it is stated that "The peach orchards have never before received such a visitation of curl as this year."

It may be assumed that the weather of one season affects the vegetation of the next, and it should be borne in mind that the summer of 1897 was a very wet one. In the six months of the growing season, namely: April, May, June, July, August and September, all except September had a rainfall above the average. In short, in place of the 25.01 inches for the normal there were 30.31 inches, more than a third (11.42 inches) of which fell in July. This is the heaviest rainfall for any month during the ten years that the writer has been connected with the New Jersey Experiment Station. The season that was most nearly like that of last year is that of 1889, in which five out of the six months of the growing season were above the normal in rainfall and the total was 36.87 inches. It was during this season that the precipitation for July was 10.19 inches, giving the month the second rank for rainfall for the past nine years.

As 1889 and 1897 were the two wet years of the last ten, and agree in having the heaviest precipitation during July, it will be to our purpose to note here some observations upon fungi recorded for those two years and return later to any consideration of the relation of the weather of one season to the mycological developments in the next.

In 1889 the writer spent a large fraction of his time in the study of crops by personal visitation throughout the state. It being his first year at the Experiment Station, there was no means of making any comparisons, but the mid-summer was characterized by the extensive development of parasitic fungi of various species. There was, for example, a phenomenal outbreak of the potato rot and both *Phytophthora infestans* De By. and the bacterial disease, working alone or together, carried off the main portion of the crop. Large growers throughout whole sections of the country did not harvest their potatoes, while others dug and placed them in heaps where they rotted.

The mildew of the lima bean, *Phytophthora phaseoli* Thax., was described by Dr. Thaxter in 1889 and figured in the Annual Report of the Connecticut Experiment Station for that year, where it is stated that it was first observed in September and in some cases the bean crop was greatly injured. Particular stress is laid upon the year of discovery, and its abundance because in the hree months of July, August and September for 1889 the total rainfall for New Jersey was 23.73 inches, or nearly ten inches above the average, and presumably it was as wet in Connecticut.

Of other fungi the writer calls to mind the destruction of the grape crop by Black Rot (*Physalospora Bidwellii* (Ell.)) and not trusting to memory the following is taken from the Experiment Station report for 1889 "It is no exaggeration to say that in some parts of the State it (grape crop) has been a complete failure. For example, * * * at Egg Harbor recently the writer was informed that in all that section, famous not only for the number, but for the fine quality of its grapes, the vineyards had yielded no marketable fruit."

It was the same year that the writer found for the first time *Plasmopora Cubensis* (B. & C.) in abundance upon pumpkin, squash and field cucumber, and he will never forget the impression made upon him of a large hillside apple orchard having an orange color from one end to the other due to the roestelia of the *Gymnosporangium macropus* that infested nearly every leaf and many of the twigs and fruits.

There is no question but that 1889 was a remarkable year for the abundance of rain and also for the prevalence of destructive fungi.

Coming now to 1897 it is recorded that the same potato sections were visited as in 1889 and the same story of destructive decay was listened to as related by the disappointed potato growers. *Phytophthora infestans* was so abundant in some fields that scarcely a leaf escaped its attack.

In a similar manner the bean *Phytophthora* was particularly destructive in 1897 and the list is a long one of those fungi that were pestiferous. Through a large part of the State the grapes rotted so badly that they were in some places removed by tons and burned as a check upon future ravages.

There is no question in the minds of the crop growers, but that 1897 was a year remarkable for its losses due to the ravages of fungi.

The two years we have been considering, namely, 1889 and 1897, are remarkable meteorologically for the heavy precipitation in July and for the fact that the whole growing season was wet.

In 1890 it is seen from the record there were four out of the six months above the normal, but the excess in each case was small and the total rainfall 25.75 was but little above the average: 25.01. The record shows to quote from the report for that year that "This has been a year of trouble with potatoes * * * decays of various sorts have been destructive * * * Farmers were plowing the ground for wheat paying no attention to the large crop of decayed potatoes in the soil."

It was the season that the bacterial disease came prominently into notice in New Jersey. It is in cases like this one of 1890 that one needs to remember that the fungous troubles of one season may be entailed upon the next should the conditions be at all favorable. There was a rainfall above the average for all the months except April and May and while not excessive this season followed one phenomenal for a wet July and the prevalence of fungi.

The years 1891 and 1892 were dry ones in which there was no outbreak of fungous troubles. The same is true of 1895 and 1896.

The year 1894 while not a particularly wet one is peculiar for the heavy fall of rain in May, 7.72 inches, and in September 7.46, amounts about doubling the average for those months, while the other four months were below the normal. It was a dry summer.

From the mycological standpoint the year was remarkable for the most wide-spread and destructive attack of fire blight that the writer has ever seen. Personal visitations to various fruit-growing sections of the State confirmed the written reports received that scarcely an apple or quince tree had escaped and a large percentage of pear orchards were injured.

Rainfall does not express all the meteorological conditions that need to be taken into consideration and in this connection it should be stated that the precipitation from May 1st to June 7th was double that of the average and from June 7th to 17th there were ten days following directly upon the heavy rains when the temperature in the day was unusually high with remarkably cool nights alternating. In short there was a long period of cloudy, rainy weather followed by a superheated period as above mentioned.

It was in the wake of these phenomenal meteorological changes that the blight came. This was the beginning of an entire loss of faith in the "iron clad" nature of the "Keiffer" pear and the year when many fruit growers determined that the "Smith's cider" apple was a variety no longer profitable simply because of its susceptibility to the blight. Orchards of pears were so badly crippled in 1894 that their recovery has been slow where ruin was not complete.

Turning to the printed notes for other fruits for the same year it is found under the Cherry leaf spot fungus (*Cylindrosporium padi* Karst.) that "never before has the writer seen such an abundance of this destructive parasite. It was impossible to find a single tree that was not more or less affected by this fungus and in hundreds of instances whole orchards were strikingly reddened by it."

Peaches were spotting badly with the *Cladosporium carpophilum* Thüm., as early as June 10th and particularly abundant upon the foliage, giving it a very distressing appearance.

The heavy September rains came late in the growing season and did not seem to have any marked effect upon the health of the ordinary crop plants for that autumn.

The next season, however, was one in which blight prevailed, but to a less extent than in 1894. The rains were somewhat excessive in April, 4.88 inches, followed by five months that in rainfall were below the average.

In connection with a bacterial disease like the fire blight, one is not yet able to decide how much of the progress of the disease may be ascribed to the previous rainy autumn and the wet early spring and we must not forget that the year before was remarkable for blight, thereby leaving a vast stock of germs on hand for future development.

It remains to consider in brief the year 1896, which, as a whole, was a dry one with a rainy June and July. It was during this time that the asparagus rust *Puccinia asparagi* DC., made its appearance in the Eastern United States to an alarming extent. The records show that the same disease reappeared in 1897 in even greater abundance, at least in New Jersey, and the wet season closed with the asparagus beds literally brown from the ravages of the rust.

It is too soon to predict in more than in a general way the outcome of a crop when the main features of the weather are given.

(More clear than any other are the possibilities of forecasting for the downy mildews.) The potato *Phytopthora* is quite likely to come when there is a wet June, July and August, as shown by the experience of 1889 and 1897.

The observed facts in connection with *Peronospora* and a dry season may not be amiss. During 1887, while in Iowa, it was recorded that from March to August there was only 8.32 inches of rainfall, followed by nearly ten inches in September. A study was made of the downy mildews and the following note was recorded in a bulletin of the Botanical Department of the Iowa Agricultural College for the year: "These observed facts show that with the Peronosporeae there is no doubt that the species are best suited to a moist season. The members of the genus *Peronospora* have in no instance been so abundant during the last two dry years as before the drought came. There was a decided decrease of the mildews the past year until the September rains came, and after that a few weeks of warm weather followed, during which seedlings of various kinds sprung up, and on these, in some instances, Peronosporae made their appearance. In general the mildews were found in early spring and after this, through the long dry summer, in limited quantities, upon plants growing in moist places along streams and edges of pools."

The genus *Cystopus* seems less influenced by drought, but as a rule there was less of the species and the infested specimens were those best situated for obtaining moisture. In all cases where Peronosporeae flourished they were upon succulent hosts, and even with these there were probably less growth of parasites but greater manifestation of disease due to lack of vitality in the hosts. These instances, therefore, form no exception to the general rule, that dry weather is not advantageous for the development of the Peronosporeae. The apple rust and the black rot of the grape come in the same category with the potato rot.

With the twig blights due to bacteria that spread most largely in early summer from flower to flower by means of bees or to the tender opening leaf buds the case is different. This would seem to be favored by a wet early spring as evidenced by the remarkable outbreak in 1894, when, in May, 7.72 inches of rain fell, the third largest monthly precipitation during the nine years.

There are no extensive data in connection with the asparagus rust as it was unknown here until 1896, but during the two years it has appeared the midsummers have been wet, but only slightly so in 1896 and not at all comparable with 1889 and 1897, when the July rains attained to 10.19 and 11.42 inches respectively and potato rot and bean *Phytophthora* prevailed.

The observations thus far made are not sufficient for any generalization, but the evidence points to the opinion that a wet April and May will prepare the way for an abundance of fungi that come in early June. This will include particularly the bacterial troubles of the orchard and fruit garden.

A wet June and July is apt to bring a failure, whole or partial, of the potato crop almost as certainly as the decay of stone fruits with *Monilia.* And should August be rainy in addition the chances of a grape crop become very small.

As has been suggested, the rain gauge does not tell the whole story. There may be cloudy weather without rainfall and great humidity without precipitation. Therefore guiding principles are far to seek so long as the several meteorological factors admit of infinite combinations.

The problem as it lies before us does not lend itself easily to the experimental method, simply because climate cannot be varied at will and applied locally as the student may desire. Something may be done in supplying water artificially in the various ways of modern irrigation; but this does not affect the atmosphere that plays in far reaching breezes, blowing for days at a time and from long distances. However, something has been attempted in this direction at the New Jersey Experiment Station and the following is gathered from the notes upon the subject. With turnips the irrigation experiments in 1896 showed that water may be applied to advantage in a dry season, "provided the ground was not infested with club-root, in which case the additional water only increased the virulence of the root malady."

The same printed report shows that for tomatoes the larger amount of fruit decay is upon the irrigated land, partly due to their being a larger percentage of those that cracked and became worthless. The irrigated plants presented a somewhat better appearance than those not receiving water, because there was more new growth; but not from any lack of the blight *Septoria lycopersici* Speg.

With the beans the report reads "The anthracnose *Colletotrichum lagenarum* (Pass.) was more than twice as abundant upon the irrigate than upon the check belt, but with the bacterial disease the amounts were reversed." In another field where beans had not been previously grown the irrigated land gave nearly double the anthracnose found upon the check and here also the bacteriosis was less than where the plants were not watered.

With potatoes and beets the results were negative, that is, there was no marked difference between the irrigated and non-irrigated in the amount of scab or leaf blights. With celery there was considerable gain in crop and an apparent decrease of the blight.

Another line of experimentation upon the general subject of weather versus fungus growth is by shading the plants partially as if in imitation of an overcast sky. During 1897 several garden crops were partially shaded by placing lath frames over the plants and cutting off one-half of the direct sun.

No striking results were obtained concerning the development of fungi and as the experiments are still running no report will be made for them here.

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